SEDIMENT EROSION PROCESS

Attachments

- Draft Sediment Management and Monitoring Plan
- Executive Summary of Sediment Monitoring Plan
- Memo – Application of the Report Entitled “Sediment Analysis and Modeling of the River Erosion Alternative”
- Technical Workshop on Nearshore Restoration in the Central Strait of Juan de Fuca
- Final Draft – Glines Canyon Dam-Lake Mills Reservoir Revegetation Plan

Sediment Erosion Process

Dam Removal - Sediment Erosion Process

Text for inclusion in the Elwha River Restoration Project JARPA
All bold text is copied from the JARPA application. All responses are in normal text.

SECTION 2

4. NAME, ADDRESS, AND PHONE NUMBER OF PROPERTY OWNER(S), IF OTHER THAN APPLICANT.
National Park Service - Olympic National Park

5. LOCATION (STREET ADDRESS, INCLUDING CITY, COUNTY AND ZIP CODE, WHERE PROPOSED ACTIVITY EXISTS OR WILL OCCUR)
Elwha River from RM 16 to RM 0.0 below the OHWM

LOCAL GOVERNMENT WITH JURISDICTION (CITY OR COUNTY)
Olympic National Park, Clallam County, and Lower Elwha Klallam Tribe.

WATERBODY
Elwha River

TRIBUTARY OF
N/A

WRIA#
18

LEGAL DESCRIPTION
NE ¼, Sec 32, T29N, R7W northward to SE ¼ Sec 27, T31N, R7W all within the OHWM of the Elwha River

SHORELINE DESIGNATION
NPS - N/A
Clallam County – Conservancy
LEKT – N/A

DNR STREAM TYPE, IF KNOWN
F

6. DESCRIBE THE CURRENT USE OF THE PROPERTY, AND THE STRUCTURES EXISTING ON THE PROPERTY. IF ANY PORTION OF THE PROPOSED ACTIVITY IS ALREADY COMPLETED ON THIS PROPERTY, INDICATE THE MONTH AND YEAR OF COMPLETION.
Upstream of Lake Mills the Geyser Valley (also known as Krause Bottom) is the first wide alluvial bottom land above Lake Mills and consists of a wide, meandering alluvial channel between the upstream Grand Canyon and downstream Rica Canyon. This alternating alluvial-and-canyon form is also typical of the region from Lake Mills to Lake Aldwell, and provides a good illustration of pre-dam conditions at Lake Mills and much of the middle reach of the river. Rica Canyon has steep rock walls and is inundated near its downstream end by Lake Mills. Since the dams have been in place, most of the sediment transported by the Elwha River has deposited within Rica Canyon as large, aggrading bars and in Lake Mills (known as Smoky bottom before it was covered with water) as delta and lake-bottom sediments.

There are several sources of information about the characteristics of Smoky Bottom, the area now occupied by Lake Mills, before the Glines Canyon Dam was built. A map made prior to dam construction in 1921 and several photographs of the reservoir area taken before inundation show a broad, slightly meandering, and locally braided channel with gravel and cobble bars with an average slope of 0.7%. The channel was bordered by extensive, gently sloping terraces up to 800 feet wide

Lake Mills now inundates a 2.5 mile stretch of the river. The Glines Canyon Dam has trapped an estimated 13.8 million cubic yards of sediment and created the Lake Mills delta. The upstream portion of the delta in Rica Canyon and Cat and Boulder Creek fans is approximately 1.55 million cubic yards of mostly coarse (i.e., sand-sized and larger) material. The main delta contains 6.97 million cubic yards which is 70 feet thick in some places. Downstream of the delta, 6.6 million cubic yards of fine, lake-bottom sediments are composed primarily of silt and clay, with minor amounts of sand. This fine material, spread fairly evenly to an estimated 12-foot thickness along the length of the lake, is concentrated in the center of the reservoir and thins toward the edges. Most of the lakebed is composed of silt-sized particles. The clay-size particles have little cohesion and lack many common properties of clay.

The first mile of the middle reach of the river immediately below the Glines Canyon Dam is constrained in a narrow bedrock canyon 80-250 feet wide. From the Altaire bridge on Olympic Hot Springs Road (river mile 12.5) to the McDonald stream gauge (river mile 8.5), the river channel is 200-400 feet wide. Overall channel slope of the middle reach is 0.7%. Different from the river processes that occurred before the dams were built, there is now little reworking of valley alluvium by lateral channel migration in the middle reach. Also, the amount of sand and gravel in the riverbed is noticeably lacking compared to the river upstream from Lake Mills. Downstream of the dam there has been noticeable scouring of fine sediment from channel edges and the floodplain.

Lake Aldwell inundates 2.8 miles of the Elwha River; the reservoir area consists of two wide alluvial reaches divided by a canyon. Approximately 3.88 million cubic yards of sediment are trapped in Lake Aldwell and its delta. The delta contains an estimated 1.78 million cubic yards, as much as 40 feet thick, composed of sand and gravel with smaller amounts of clay, silt, cobbles, and boulders. Downstream of this delta, 2.1 million cubic yards of fine, lake-bottom sediments are composed of fine-grained sediments, with minor amounts of sand. This material is 5-6 feet thick in the southern basin, thinning to less than 1 foot in the narrow canyon section.

From the Elwha Dam down to river mile 4, the river is constrained by the steep bedrock walls of Elwha Canyon. In the next half mile of the river below Elwha Canyon, the stream gradient is less steep and the channel floodway widens to approximately 1,500 feet. At river mile 2.8, the river channel is constrained by bedrock on the right bank and narrows through this area.

Between river mile 2.8 and the river mouth, the floodplain widens and is bound on the west side by steep cliffs of glacial deposits more than 150 feet high. The pre-dam river migrated throughout its entire floodplain; nearer the mouth, it moved laterally over an area 1.2 miles wide. The erosion action of the meandering river traditionally prevented the establishment of a mature evergreen forest. Because the channel has shifted less frequently since the dams were built, dense, woody vegetation has grown in near the mouth and serves to increasingly constrain the river in the lower reach. The Lower Elwha Federal Flood Control Levee, situated on the east side of the floodplain, constrains the eastward migration of the river. A 900-foot-long privately owned levee extending downstream from the high river bluffs on the west side of the river near its mouth also restricts the floodplain on its west side.

For thousands of years, erosion and river transport delivered sediment to the Elwha River mouth to form an extensive delta. The delta is roughly 5 miles wide, 6 miles long, and estimated to be 200 feet thick. It is composed of sand, gravel, and cobbles, with samples indicating a sand and gravel surface to approximately 2,000 feet offshore (COE 1971). The dams blocked this natural sediment transport; currently, the only sources of delta sediment are those in the 4.9 miles upstream from the mouth, i.e., erosion of loose material (alluvium) and from the bluffs that lie along the west side of the river. As a result, sediment yields to the delta have dropped from a pre-dam sediment supply of 280,000 cubic yards per year to 5,900 cubic yards per year, approximately 2% of the pre-dam volume (Schwartz 1994; FERC 1993).

In the pre-dams period the sediment from the Elwha delta moved with the currents in the strait, predominantly in an eastward direction along the coast. The sediment nourished beaches and nearshore areas with sand and gravel, and supplying some of the sediment to Ediz Hook. The drastic reduction in bedload sediment supply from the river has caused beach erosion and erosion on the western edge of Ediz Hook.

Structures within the OHWM of the Elwha River include Glines Canyon Dam, Elwha Dam, three highway bridges, City of Port Angeles M&I water diversion and a Clallam county flood control levee at the mouth of the river.

IS THIS PROPERTY ON AGRICULTURAL LAND?
No

ARE YOU A USDA PROGRAM PARTICIPANT?
No

7.a. DESCRIBE THE PROPOSED CONSTRUCTION AND/OR FILL WORK FOR THE PROJECT THAT YOU WANT TO BUILD THAT NEEDS AQUATIC PERMITS: COMPLETE PLANS AND SPECIFICATIONS SHOULD BE PROVIDED FOR ALL WORK WATERWARD OF THE ORDINARY HIGH WATER MARK OR LINE, INCLUDING TYPES OF EQUIPMENT TO BE USED. IF APPLYING FOR A SHORELINE PERMIT, DESCRIBE ALL WORK WITHIN AND BEYOND 200 FEET OF THE ORDINARY HIGH WATER MARK. ATTACH A SEPARATE SHEET IF ADDITIONAL SPACE IS NEEDED.
The proposed action would allow the sediments presently trapped in Lake Mills and Lake Aldwell to be eroded from the reservoirs (to the extent possible) and transported downstream to the Strait of Juan de Fuca by natural processes. See Figure 1

River erosion is a minimum cost option for sediment management (Randle and Lyons 1995). Except for controlling lake elevations during reservoir drawdown and the rate at which each dam is removed, the river initially would be allowed to erode reservoir sediment without mechanical intervention (such as hydraulic dredging). However, re-contouring of the remaining sediment to achieve a stable slope configuration may be necessary.

The rate of sediment release from the dam would depend on the rate of dam removal, lake inflow, and sediment particle size. Slow rates of sediment release would tend to reduce the magnitude of short-term effects but would increase the duration of those effects, high rates of sediment release would tend to reduce the duration of short-term impacts but increase their magnitude. In the case of fish, even slow rates of fine-grained sediment release may prove to be lethal or cause fish to avoid entering the river. Therefore, high magnitude, short-duration impacts would be preferred over low-magnitude, long-duration impacts. Elwha and Glines Canyon dams would be removed over a two-year period to minimize the duration of high sediment concentrations in the river.

For both lakes, water surface elevations would be controlled during reservoir drawdown. Each lake would be drawn down in stages in order to redistribute reservoir delta sediments within the reservoir. After each increment of drawdown, the lake levels would generally be held constant for about two weeks. These drawdown stages would continue until the lakes are completely drained. Delta sediments of both lakes would erode and redeposit, forming a sequence of new deltas downstream (corresponding to the two-week drawdown increments), and temporarily covering the existing lake bed sediments. Deposition of delta sediment farther downstream within the reservoir is expected to be uniform across the reservoir and eventually reach the dam. The slope of the re-deposited delta material would largely depend on the sediment particle size and river flow. No significant quantities of coarse-grained sediment would be released beyond the dam

Sediment Erosion Process

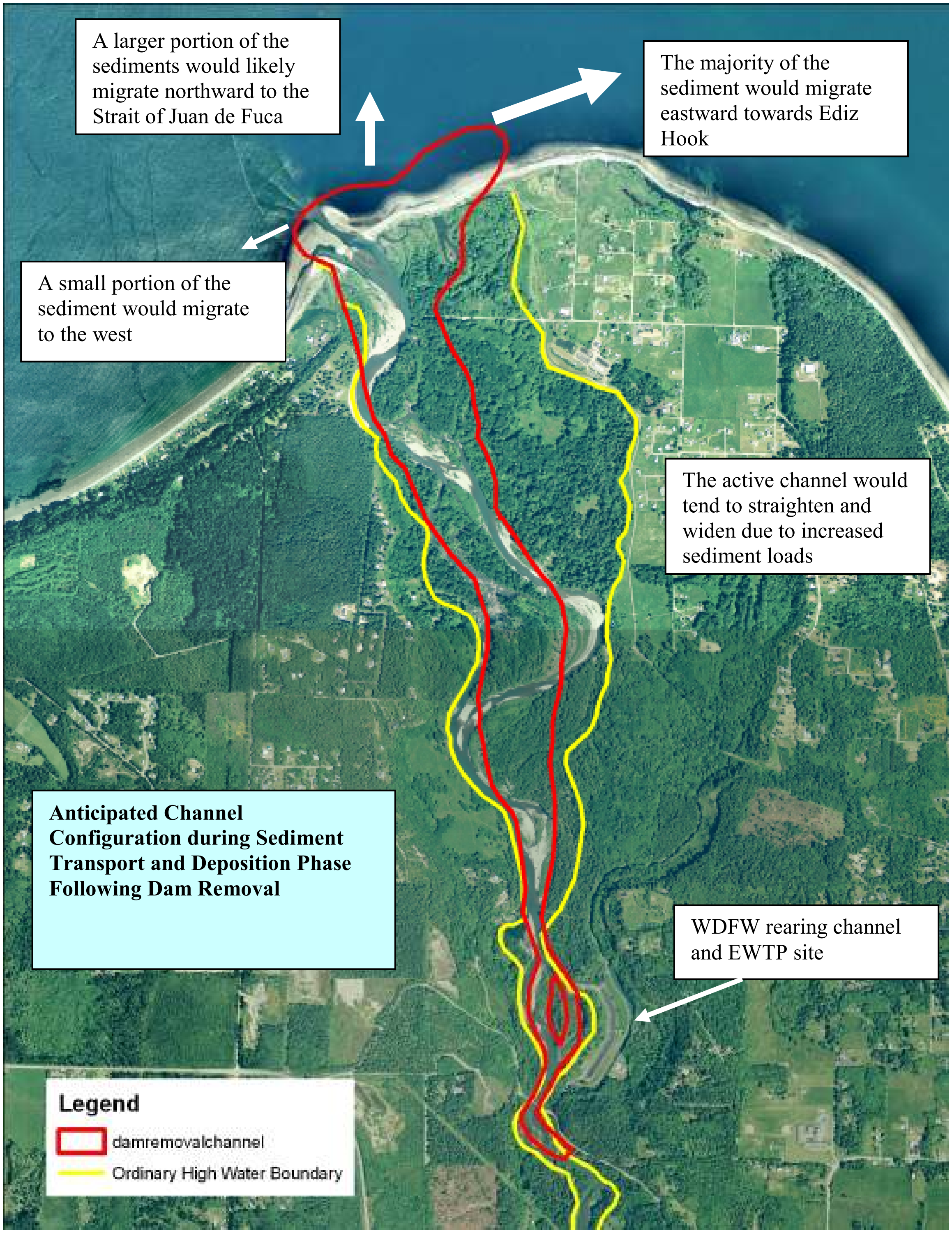

Figure 1. Conceptual drawing of potential active channel width during dam removal when sediment loads will be higher than existing conditions. Background aerial photo from 2005 with ordinary high water mark boundary shown for reference.

sites until the dams are removed down to an elevation near the top of the re-deposited deltas. Dam removal below this elevation would result in the release of high sediment concentrations.

For both lakes, fine-grained sediments would erode much faster than coarse-grained sediments. Some boulders and cobbles present in the upstream portions of the delta may not erode at all. For a given peak river flow during the initial erosion process, an armor layer of cobbles and boulders may develop that would prevent the erosion of finer sediments underneath. The potential armor layer and the underlying sediments would be eroded later by higher river flows of sufficient duration. Since the volume of cobbles and boulders is relatively small, any armor layers would be left to natural processes unless they impede fish passage. If necessary, erosion of this armor layer would be initiated by blasting to allow fish to swim upstream.

River and estuary conditions (both physical and biological) and water intakes would be extensively monitored during the erosion of reservoir sediments. Monitoring information could be used to adjust the rate of dam removal and, therefore, the rate of sediment release. Sediment would be released as rapidly as possible to minimize the duration of impacts, but without exceeding the river's sediment transport capacity or the capacity to treat municipal and industrial water. (See Table 1 for quantities and composition)

7.b. DESCRIBE THE PURPOSE OF THE PROPOSED WORK AND WHY YOU WANT OR NEED TO PERFORM IT AT THE SITE. PLEASE EXPLAIN ANY SPECIFIC NEEDS THAT HAVE INFLUENCED THE DESIGN.

The Elwha River Ecosystem and Fisheries Restoration Act (Public Law 102-495), passed by Congress in 1992, requires the "…full restoration of the Elwha River ecosystem and native anadromous fisheries." The removal of Elwha and Glines Canyon Dams was determined by the Secretary of the Interior to be the only alternative that would achieve the goal desired by Congress. The plan to meet this goal includes the following objectives:

- Safely remove Elwha and Glines Canyon Dams.
- Accommodate river flows during dam removal, through diversion channels and excavated notches.
- Facilitate sediment management through controlled releases and systematic construction schedules.
- Address environmental issues by planning work shutdowns during certain periods.
- Retain certain structures for historical preservation at Glines Canyon Dam, allowing public viewing of the site from structures on both abutments and retaining the historic powerhouse.
- Achieve reasonable costs by limiting structure removal at Glines Canyon Dam and by selecting construction methods that are economical but do not sacrifice safety.

The Elwha River below Glines Canyon Dam meanders less frequently and over less of its floodplain than before the dams were built. This is because sediment transport has been blocked, and riverbed sand and gravel are largely absent. The loss of riverbed material has also dropped the river's elevation, and the water is now more often confined within the channel boundaries. The river bottom is armored with larger rocks and boulders, which move only in the largest floods. This contributes to channelized, rather than meandering river morphology. Because the movement of bedload scours and redeposits on the streambed, vegetation cannot easily establish itself in most sand- and gravel-bed rivers. However, in the Elwha, gravel bars have become stabilized and well vegetated. The loss of streambed materials and its effect on reducing the meandering nature of the river have significant implications for native and anadromous fish species. In addition to altering the channel morphology, the dams have resulted in direct impacts to the river by inundating 5.3 miles of the Elwha River. A map of the Lake Mills area made prior to dam construction in 1921 and several photographs of the reservoir area taken before inundation show a broad, slightly meandering and locally braided channel with gravel and cobble bars with an average slope of 0.7%. The channel was bordered by extensive, gently sloping terraces up to 800 feet wide.

Sediment Erosion Process

Lake Mills now inundates 2.5 miles of the Elwha River. The Glines Canyon Dam has trapped an estimated 13.82 million cubic yards of sediment and created the Lake Mills delta. The upstream portion of the delta in Rica Canyon and the Cat and Boulder Creek fans contain approximately 1.55 million cubic yards of mostly coarse-grained material. The main delta contains 6.97 million cubic yards, up to 70 feet thick in some areas. Downstream of the delta are 5.3 million cubic yards of fine-grained lake-bottom sediments composed mostly of silt, clay and some sand-sized materials.

Lake Aldwell inundates 2.8 miles of the Elwha River. The reservoir consists of two wide alluvial reaches divided by a bedrock ridge. Approximately 3.88 million cubic yards of sediment are trapped in Lake Aldwell and its delta. The main delta contains an estimated 1.78 million cubic yards, and is as much as 40 feet thick. About 2.1 million cubic yards of fine-grained material lie in the lakebed downstream fro the delta.

The pre-dam river migrated throughout its entire floodplain; nearer the mouth, it moved laterally over an area 1.2 miles wide. The erosion action of the meandering river prevented the establishment of a mature evergreen forest. Because the channel has shifted less frequently since the dams were built, dense, woody vegetation has grown in near the mouth and serves to increasingly constrain the river in the lower reach. The federal Lower Elwha flood control levee, situated on the east side of the floodplain, confines the eastward migration of the river. Constructed in 1988, the levee was built to withstand the 200-year flood and to provide flood protection for approximately 300 acres in the lower Elwha River floodplain. Based on empirical relationships and historical evidence from aerial photographs, the levee was located beyond the limits of the river meander-belt width.

A 900-foot-long privately owned levee extending downstream from the high river bluffs on the west side of the river near its mouth also restricts the floodplain.

The dams continue to block the natural supply of coarse-grained sediment to the river downstream. The only sources of coarse sediment are those in the 3 miles upstream from the mouth, i.e., erosion of loose material (alluvium) and of the bluffs that lie along the west side of the river. As a result, sediment yields to the delta have dropped to 5900 cubic yards per year, or approximately 2% of the pre-dam volume. The drastic reduction in coarse-grained sediment supply from the river has caused some beach erosion and erosion of the western edge of Ediz Hook.

The US Army Corps of Engineers, which spends approximately $100,000 annually (January 1995 figures) to control further erosion of Ediz Hook, estimates that sediment supplied from the river before the dams were built was between 50,000 and 80,000 cubic yards per year. Currently, the river contributes a negligible volume of sediment to Ediz Hook. Marine cliffs east of the river mouth also supplied sediment to the beaches and Ediz Hook, but this source, too, has been vastly reduced. In 1930 and again in 1958, these cliffs were stabilized to control erosion and to protect a city water supply pipeline at their base. It is estimated that the dams on the Elwha River have reduced sediment supply to the coastal zone between the Elwha River mouth and Ediz Hook by approximately 35%. Stabilization of the marine cliffs is estimated to have reduced beach and hook sediment supply by 55%.

The dams have had a major impact on the character of the Elwha River and nearshore area. The river channel is armored and meanders over less of its floodplain as a result of the decreased sediment supply. Reduced amounts of sand and gravel delivery to the river mouth and coastal areas exacerbate the coastal erosion in the Angeles Point and Ediz Hook areas and cause further recession of the offshore delta. These impacts would be reversed through implementation of the proposed action.

Sediment Erosion Process

7.c. DESCRIBE THE POTENTIAL IMPACTS TO THE CHARACTERISTIC USES OF THE WATER BODY. THESE USES MAY INCLUDE FISH OR AQUATIC LIFE, WATER QUALITY, WATER SUPPLY, RECREATION AND AESTHETICS. IDENTIFY PROPOSED ACTIONS TO AVOID, MINIMIZE, OR MITIGATE DETRIMENTAL IMPACTS, AND PROVIDE PROPER PROTECTION OF FISH AND AQUATIC LIFE. ATTACH A SEPARATE SHEET IF ADDITIONAL SPACE IS NEEDED.

Mitigation measures presented here are considered integral to the project, and are required either by law or regulation or to achieve goals or directives in the Elwha River Ecosystem and Fisheries Restoration Act (PL 102-495). Other mitigation measures not specifically required, but desirable to minimize impacts to important resources, are recommended, and would be added depending on project funding.

Both Elwha and Glines Canyon dams would be removed in controlled increments; there are no plans to suddenly breach either dam. Since there is no low-level release capability from either dam (to drain reservoirs or remove sediment), removal plans include river diversion options.

The plan to remove Glines Canyon Dam focuses on notching down the dam. Lake Mills would be drained through these notches cut into the dam, allowing the part of the dam above the notches to be removed while dry.

The removal of Elwha Dam is more complicated than the removal of Glines Canyon Dam. The alluvium under Elwha Dam eroded upon initial filling of Lake Aldwell which caused a large void under the gravity section. The breach was repaired by filling the area upstream and downstream of the dam with rock debris blasted from the canyon walls. Other fill material, including sand and gravel, a fir mattress, and a gunite cap (sprayed concrete), was subsequently placed to control seepage. However, the void still exists under the gravity section. This fill material is now considered part of the dam, and its removal under full lake conditions could potentially cause another failure (water flowing under the dam). A sequence of cofferdams and diversion channels is necessary for the safe removal of Elwha Dam. (Refer to Dam Removal JARPA Data for specific dam removal description.)

General Impacts

Short-term Impacts due to Construction Include:

- Increase in suspended sediments and turbidity affecting fish and aquatic life and water quality for 2-5 years.
- Localized modification of river hydrology affecting fish and aquatic life.
- Undetermined volume of eroded negatively impacting riverine wetlands and the estuary. The Implementation EIS estimates that a portion of 43 acres may be lost.

Long-term Impacts Include:

- Alteration of the character of the streambed and the river hydrology affecting fish and aquatic life.
- Increase in wetland acres due to the addition of fine grained sediments. The Implementation EIS estimates that 48 acres of vegetated and 122 acres of unvegetated wetlands would be restored.
- Increase in fish populations in the watershed by improving fish passage characteristics of this section of the Elwha River.

Specific Impacts

IMPACT TOPIC	**IMPACT**
River Erosion	
Reservoir areas	1.2-2.7 million cubic yards of coarse, and 4.7-5.6 million cubic yards of fine sediment would erode from reservoirs.

Sediment Erosion Process

Downstream channel	Fine-grained sediment and sand would move rapidly downstream, approaching background levels in 2 to 6 years; coarse sediments deposit and aggrade riverbed; more meandering and streambank erosion would be a beneficial impact
Delta, beaches and Ediz Hook	Re-establish sediment supply, rebuilding of beaches and delta within 3 years; begin to reverse erosion of Ediz Hook within 5-10 years.
FLOODING	
Increases in water surface elevation, aggradation	Riverbed aggradation would cause increases in river stage of up to 4 feet; mandatory mitigation on federal levee and for municipal and industrial water wells would provide current level of flood protection; without recommended mitigation other areas may experience major impacts due to more frequent flooding (not significantly different than existing conditions).
SURFACE WATER	
Short-term (during dam removal) critical indicators	
Total suspended solids in river (peak concentrations)	28,000 to 51,000 parts per million-major adverse impact for 1 to 3 day periods.
Total manganese	500 to 10,000 micrograms per liter maximum for 1-3 day periods – possible major adverse impact to water quality
Turbidity	2,000 to 25,000 NTU's maximum for 1-3 day periods – major adverse impact.
PH during dam removal	5 to 9 – minor change.
Temperature (Celsius) during dam removal	15^{o} C to 19^{o} C – minor to major beneficial impact.
Dissolved oxygen during dam removal	90 to 100% - minor change.
Long-term (from 1 year after dam removal) critical water quality indicators	
Total suspended solids in river	Average 69 parts per million within 2 years after dam removal – moderate adverse impact.
Turbidity	1 to 1000 NTU's within 2 years following dam removal – moderate adverse impact
Dissolved iron	10 to 5,000 micrograms per liter within 2 years – minor adverse impact to water quality.
Dissolved manganese	10 to 700 micrograms per liter within 2 years following dam

Sediment Erosion Process

	removal – minor adverse impact to water quality
PH	6.5 to 8.5 – minor beneficial impact.
Temperature (Celsius)	15^{o} C to 17^{o} C – major beneficial impact.
Dissolved oxygen	95 to 110% - no change over existing conditions.
NATIVE RESIDENT AND ANADROMOUS FISHERIES	
Long-term restoration	All Elwha River anadromous fish stock except sockeye salmon fully restored within 20 years. Hatchery support, out-planting, harvest management, and optimal timing of dam removal could halve restoration time.
Species-specific restoration potential	The Elwha River could eventually produce an estimated 31,000 returning chinook salmon, 35,000 coho salmon, 274,000 pink salmon, 36,000 chum salmon, 10,000 steelhead, and 6,500 sockeye salmon per year.
Short-term impacts	The release of fine sediment during and following dam removal would cause mortalities, physiological stress, or displacement of fish in the river for up to four years, and cause returning adults to avoid migrating up the river. Hatchery support, out-planting, harvest management, and optimal timing of dam removal would help protect fish during this period.
Chinook salmon	Direct fish loss caused by extreme sediment. Hatchery support and out-planting would replace fish lost to high sediment levels and begin to reestablish stock in the middle and upper Elwha River.
Coho salmon	Same as for Chinook Salmon.
Pink salmon	Direct loss, if pinks present, caused by extreme sediment levels. Hatchery support and out-planting of Dungeness stock would begin to reestablish pink salmon in the Elwha River.
Chum salmon	Direct fish loss caused by extreme sediment levels. Hatchery support and out-planting would reduce adult fish loss and replace young fish lost caused by high sediment levels. Begin to reestablish stock in the middle and upper Elwha River.
Sockeye salmon	No direct fish loss caused by extreme sediment levels. There would be no hatchery or out-planting effects. The existing Lake Sutherland kokanee population may eventually reestablish a native sockeye run.
Steelhead	Same as for Chum Salmon.
Sea-run cutthroat & char	Direct fish loss caused by extreme sediment levels. There would be no hatchery or out-planting effects. Natural recolonization by

	remnant stocks would eventually reestablish anadromous populations.
VEGETATION	
Restored communities	562 acres of vegetated lands would recover: 514 of forested lands and 48 of other vegetation.
Riparian communities	5.3 miles returned
Wetlands	Portion of 223 acres may be affected by filling or flooding; 48 acres of vegetated and 122 acres of unvegetated wetlands would be restored
WILDLIFE	
Terrestrial habitat including elk and other mammals, trumpeter swans and other birds	Restoration of habitat and fish runs would be a major beneficial impact to most species including elk. Species dependent on the reservoirs, including trumpeter swans, would lose habitat, but regional impacts would be minor.
SPECIES OF SPECIAL CONCERN	
Federally listed species: bald eagle, northern spotted owl, marbled murrelet, Steller sea lion, Orca, humpback whale, chinook, and bull trout	Bull trout, chinook, and murrelets would be adversely impacted in the short term (2 to 5 years) by noise and turbidity. Return of salmon as prey and upland forest as habitat would have a major beneficial impact on murrelets, bald eagles, and spotted owls in the long term. Chinook would experience a long term major benefit from the access to spawning habitat. Measures would be implemented for bull trout protection based on the requirements of the Biological Opinion. Sea lions would experience minor beneficial and no impacts, respectively.
Federal species rated “of concern” include Pacific fisher, harlequin duck, northern red-legged frog, and coho.	Harlequin ducks would sustain short-term, minor impacts. Coho would be adversely impacted in the short term. All species would sustain major beneficial impacts in the long term.
Species or stocks considered for federal listing: steelhead, and sea-run cutthroat trout	All species would be adversely impacted in the short term, but over the long-term, restoration would offset some cumulative impacts occurring elsewhere in the region.
Candidates for state listing including pileated woodpecker, Van Dyke’s salamander, and Vaux’s swift	All species would sustain major beneficial impacts in the long term.

Sediment Erosion Process

LIVING MARINE RESOURCES	
Nearshore marine communities	Moderate adverse impacts would occur to local marine communities from silt and clay transported by the river. A major change would occur, from transport of sand and gravel, in the substrate and biological community at the river mouth and to the east. However, future conditions would approximate pre-dam conditions.
CULTURAL RESOURCES	
Construction related impacts	Major adverse effect to hydroelectric projects. Mitigation through HABS/HAER documentation and leaving some structures in place at Glines reduces impacts to minor. Permanent, major beneficial impacts to cultural resources important to the tribe by making previously inundated resources accessible. Minor to negligible impacts, with mitigation, to cultural resources and cultural landscapes in the immediate vicinity of dam sites.
Offsite disposal of dam rubble	Minor impacts, with mitigation.
Increased flooding and erosion	Minor impacts, with mitigation, to sites potentially affected by increased flooding and erosion.
Construction of access roads and staging areas	Moderate, short-term impacts to Elwha Ranger Station Historic District, Altaire and Elwha campgrounds kitchen shelters, known and potential landscapes, culturally sensitive areas, known and unknown archeological sites if roads built near or these areas are used for access/staging of equipment. With mitigation, impact minor.

Specific Mitigation Measures

SUMMARY OF MITIGATION MEASURES FOR RIVER EROSION	PART OF ACTION	RECOMMENDED MITIGATION
Fluvial Processes and Sediment Transport		
Long-term sediment monitoring (cross-sections, air photos, stream gauging)	X	
Flooding (see Flood Protection)		
Water Quality (see Water Quality Mitigation)		
Fisheries		
Gradual/intermittent release of water and sediment from reservoir		X

Sediment Erosion Process

SUMMARY OF MITIGATION MEASURES FOR RIVER EROSION	PART OF ACTION	RECOMMENDED MITIGATION
Prior to dam removal, out-plant eggs or fry in upper river	X	
Shut down dam removal activities to ensure minimum river flows	X	
Stop construction during high flows to protect fish (November and May to June)	X	
Develop broodstocks, out-plant juveniles, and evaluate adult return during and after dam removal	X	
Construct new Lower Elwha Klallam Tribal Fish Hatchery and pipeline	X	
Vegetation (see attached Revegetation Plan)		
Wildlife		
Trumpeter Swan mitigation		X
Species of Special Concern		
Noise reduction measures or changes in sequencing and timing of construction activities	X	
Bull Trout fish passage at Huges and Griff Creeks	X	
Cultural Resources (see three party Programmatic Agreement)	X	

Following dam removal, sediment monitoring and management and the revegetation program are the key to successful ecosystem restoration.

Sediment Management and Monitoring

Natural river processes would be, for the most part, allowed to erode the reservoir areas. The rate and amount of reservoir sediment erosion would depend on the dam notching rate, river and tributary flows, and the frequency and intensity of rainfall. The amount of river sediment transport would mostly depend on the river discharge and phase of the notching cycle. Monitoring of channel aggradation conditions, water quality, and fisheries restoration needs would guide some adjustments to the dam removal rate and subsequent sediment levels from Lake Mills, and is considered integral to the project. An estimated 50% of the fine sediments in Lake Mills are expected to be removed; the remainder lies outside the floodplain or is buried in coarse delta sediment.

Sediment Erosion Process

The sediment monitoring plan includes:

- repeat cross-section surveying along the river below the dams and in both reservoirs,
- repeat aerial photography of the river corridor and reservoir areas, and
- stream measurements of river flow, suspended sediment concentration, and turbidity at Goblin Gates, at McDonald Bridge, and below Elwha Dam.

The stream gauge immediately above Lake Mills at the mouth of Rica Canyon would be phased out and a new one established at Goblin Gates, the upstream entrance to Rica Canyon. The new gauge would be operated concurrently with the existing gauge above Lake Mills for approximately one year before beginning dam removal. The gauging station above Lake Mills would be removed upon the commencement of dam removal.

Although the gauge above Lake Mills is presently at a good location, it would be a poor quality measurement site during dam removal because of a continually eroding stream bed and difficult access. The location at Goblin Gates would be necessary to monitor the natural sediment supply during dam removal and to help guide operation of the pre-treatment facility for the industrial water supply. (See attached Draft - Sediment Management and Monitoring Plan)

Revegetation

The revegetation goal for the Lake Mills and Lake Aldwell lake beds would be to restore the areas to the conditions and processes that existed prior to the construction of the dams. Krause Bottom, upstream from Rica Canyon, provides a model of plant communities similar to those believed to have occurred within the former lake beds. Sweets Bottom, located between the two dams, also provides a visual model of an open, flat, terraced community, although it has been modified by settlement and clearing. The distribution and composition of native plant species within these two areas, as well as the plant communities on the slopes above the reservoirs, were used in the development of the revegetation plan.

The lake beds would be revegetated through a combination of natural recolonization and a moderately intensive program of planting native species. The dispersal of seeds from upslope and upstream areas would result in a natural reseeding of the lake beds. To accelerate succession, achieve a structurally complex forest ecosystem in a shorter time period, and limit invasion of non-native species, a variety of planting schemes would be used (see appendix 3). Methods would include seeding, use of cuttings, and planting trees of different ages. Fertilizer would be applied with selected individuals to encourage rapid stand development, and species composition would be varied to reflect plant communities on a landscape scale. Additional treatments may include placement of large organic debris and inoculating planting stock with mycorrhizal fungi. Plant materials would be collected only from the Elwha valley to maintain genetic integrity of the ecosystem; planting stock would be propagated prior to dam removal. Nonnative plant species that colonize the lake beds would be controlled or eradicated. The success of natural recolonization and planting would be evaluated annually to determine necessary modifications or remedial measures. Such measures could include the replanting of areas where survival was poor or manipulating stand density to better achieve goals.

The revegetation program would use a wide variety of native ferns, grasses, forbs, shrubs, and tree species including, but not limited to, vanilla leaf, sedge, sword fern, salmonberry, salal, Oregon grape, willow, bigleaf maple, red alder, western hemlock, Douglas-fir, and western red cedar. Individual site conditions would dictate the mix of plant species used. In wetter areas sedges, lady fern, salmonberry, black cottonwood, willow, red alder, grand fir, bigleaf maple, and western red cedar would be seeded or planted. Upslope forest species would include sword fern, native roses, huckleberry, Oregon grape, salal, western hemlock, western red cedar, and Douglas-fir. (See attached Final Draft, Glines Canyon Dam – Lake Mills Reservoir – Revegetation Plan [Lake Aldwell revegetation plan is still in preparation, but will use the same philosophy and methodology as will be used for Lake Mills.])

Sediment Erosion Process

8. WILL THE PROJECT BE CONSTRUCTED IN STAGES?
Yes, the River Erosion will occur after water quality mitigation and flood protection projects are complete.

PROPOSED STARTING DATE:
River Erosion will occur beginning in 2009. The exact starting date will be determined based on completion of water quality mitigation elements.

ESTIMATED DURATION OF ACTIVITY:
Overall ESWI construction will require approximately 36 months.

9. CHECK IF ANY STRUCTURES WILL BE PLACED:

WATERWARD OF THE ORDINARY HIGH WATER MARK OR LINE FOR FRESH OR TIDAL WATERS.
No.
WATERWARD OF MEAN HIGH WATER LINE IN TIDAL WATERS:
No.

10. WILL FILL MATERIAL (ROCK, FILL, BULKHEAD, OR OTHER MATERIAL) BE PLACED:

WATERWARD OF THE ORDINARY HIGH WATER MARK OR LINE FOR FRESH OR TIDAL WATERS.
Yes. The eroded sediments will deposited through out the Elwha River from Lake Mills to the estuary. Erosion of the lakebed sediments will cause 2.5-feet (+/- 2.5-feet) aggradation in the channel depending on localized hydrogeologic conditions.

WATERWARD OF MEAN HIGH WATER LINE IN TIDAL WATERS.
Yes. The entire estuary will be affected by the eroded sediments
See Table 1 for predicted composition and volumes

Sediment Erosion Process

Table 1. Reservoir Sediment Erosion Summary Using Four Hydrologic Periods

		Predicted Reservoir Sediment Erosion					
1994 Reservoir Sediment Volumes (yd^3)		1950 to 1963	1968 to 1981	1971 to 1984	1989 to 2002	Minimum	Maximum
Total Lake Mills Sediment	13,830,000	35%	39%	37%	34%	34%	39%
½ Sand & Gravel	7,210,000	14%	20%	16%	23%	14%	23%
½ Silt & Clay	6,620,000	58%	60%	60%	46%	46%	60%
Total Lake Aldwell Sediment	3,880,000	63%	63%	63%	64%	63%	64%
1/3 Sand & Gravel	1,290,000	71%	71%	72%	73%	71%	73%
2/3 Silt & Clay	2,590,000	59%	59%	59%	60%	59%	60%
Total Reservoir Sediment	17,710,000	41%	45%	43%	41%	41%	45%
Sand & Gravel	8,500,000	23%	28%	25%	31%	23%	31%
Silt & Clay	9,210,000	58%	60%	60%	50%	50%	60%
		Predicted Reservoir Sediment Erosion Volumes (yd^3)					
1994 Reservoir Sediment Volumes (yd^3)		1950 to 1963	1968 to 1981	1971 to 1984	1989 to 2002	Minimum	Maximum
Total Lake Mills Sediment	13,830,000	4,830,000	5,440,000	5,120,000	4,710,000	4,710,000	5,440,000
½ Sand & Gravel	7,210,000	1,010,000	1,460,000	1,160,000	1,660,000	1,010,000	1,660,000
½ Silt & Clay	6,620,000	3,820,000	3,980,000	3,960,000	3,050,000	3,050,000	3,980,000
Total Lake Aldwell Sediment	3,880,000	2,440,000	2,460,000	2,460,000	2,480,000	2,440,000	2,480,000
1/3 Sand & Gravel	1,290,000	910,000	920,000	930,000	940,000	910,000	940,000
2/3 Silt & Clay	2,590,000	1,530,000	1,540,000	1,530,000	1,540,000	1,530,000	1,540,000
Total Reservoir Sediment	17,710,000	7,270,000	7,900,000	7,580,000	7,190,000	7,190,000	7,900,000
Sand & Gravel	8,500,000	1,920,000	2,380,000	2,090,000	2,600,000	1,920,000	2,600,000
Silt & Clay	9,210,000	5,350,000	5,520,000	5,490,000	4,590,000	4,590,000	5,520,000

The reservoir sediment erosion model results are based on the simulation of four separate hydrologic periods:

- 1950 – 1963 represents a dam removal period that begins with one year of relatively high annual peak discharge, followed a year of relatively low, and then a year of moderate peak discharge.
- 1968 – 1981 represents a dam removal period that begins with the lowest peak discharges for any three consecutive water years of record.
- 1971 – 1984 represents a dam removal period that begins with progressively higher annual peak discharges in each of the first three years.
- 1989 – 2002 represents a dam removal period that begins with the highest peak discharges for any three consecutive water years of record.

11. WILL MATERIAL BE PLACED IN WETLANDS?

Yes.

IF YES,

Sediment Erosion Process

A. IMPACTED AREA IN ACRES:

The approximate acreage of riverine wetlands that may be impacted by Sediment Erosion. Erosion of the lakebed sediments will cause 2.5-feet (+/- 2.5-feet) aggradation in the channel depending on localized hydrogeologic conditions. (Acreages estimated from Sheldon and Associates, 1996 and URS, 2005)

Wetland	Acres	Wetland	Acres
1	49.00	27	13.99
4	5.30	29	2.55
5	8.9	31	3.59
6	12.43	37	6.14
7	1.65	38	10.02
8	46.24	39	2.59
9	2.4	40	3.48
11	3.59	45	18.08
12	2.83	48	0.54
13	1.01	50	0.25
16	8.09	51	0.51
21	2.19	52	9.57
26	4.7	62	3.09
Total			222.73

Wetland 1 is the estuary east of the private levee and wetlands 4 and 5 are the tidal/ground water influenced depressional wetlands west of the private levee. All other wetlands arc classified as riverine. The short term impact to these wetlands can not be quantified at this time, however the riverbed will aggrade an average of 2.5-feet and the wetlands will be subject to filling as well as flooding. In the long term the wetlands will recover and will likely enlarge depending on localized river conditions.

B. HAS A DELINEATION BEEN COMPLETED? IF YES, PLEASE SUBMIT WITH APPLICATION.
Yes

C. HAS A WETLAND REPORT BEEN PREPARED? IF YES, PLEASE SUBMIT WITH APPLICATION.
Yes

D. TYPE AND COMPOSITION OF FILL MATERIAL (E.G. SAND, ETC):
Native river alluvium impounded behind Glines Canyon and Elwha Dam. (See Table 1)

E. MATERIAL SOURCE:
Elwha River watershed.

G. WILL PROPOSED ACTIVITY CAUSE FLOODING OR DRAINING OF WETLANDS?
Flooding of wetlands may occur depending on localized aggradation.

13. WILL EXCAVATION OR DREDGING BE REQUIRED IN WATER OR WETLANDS?
No.